Computer Basics

Processors 3

The Processor

CPU voltage and transistor integration

- The voltage is the power the processor draws from the main system board, which it receives originally from the power supply.
- A processor is designed to run at a certain voltage. You need to ensure that the system board you are placing the processor into is providing that voltage. If a system board supports more than one voltage, you can change a jumper on the system board—which will then control the voltage used by the processor.
- Processors are made up of thousands, even millions, of transistors. A transistor acts as a switch, either permitting or prohibiting the flow of current. If current is allowed to flow through the transistor, then some form of result is generated. If the current is not allowed to flow through the transistor, a different result is generated.
- How does the switch get turned on to allow the flow of current? The answer is from an input device, such as the keyboard. The action of pressing keys on a keyboard sends a positive charge to the transistor to turn on the switch.

The Processor

Keeping a Processor Cool

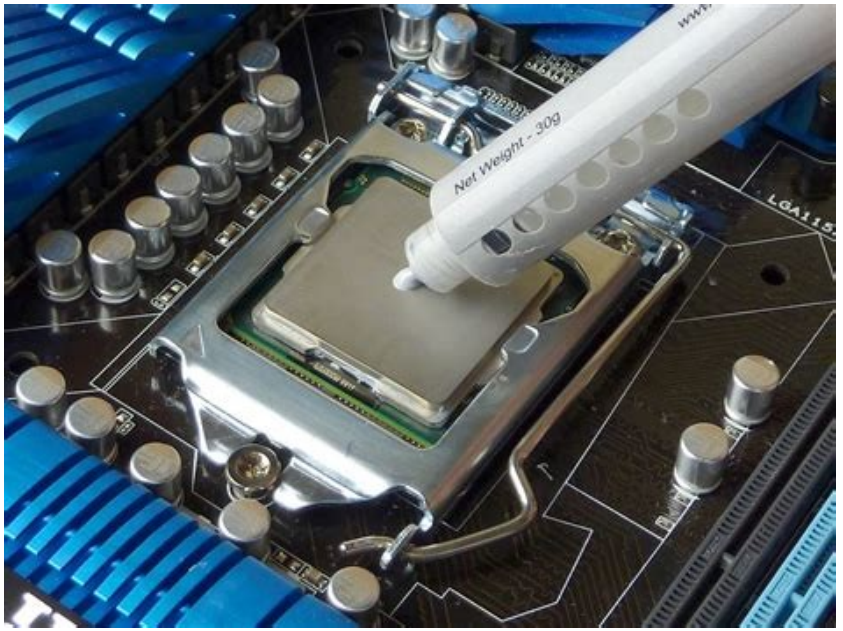
A number of other cooling devices are on the market today, and they are a little more expensive than your typical heat sink or CPU fan. The following are other cooling techniques you may find in systems today:

- **Liquid-based cooling:** A liquid cooling system pumps a cooling liquid throughout the PC by using small hoses. The benefit of a liquid cooling system is the reduced noise, but its big drawback is the amount of space needed in the PC for the components of the cooling system — and, of course, the threat of a leak if the cooling system is not installed properly.
- **Temperature sensors:** A number of processors today come with a built-in thermal sensor (a high-tech thermometer). Temperature sensors allow the processor to identify that it is overheating and then shut itself down until the temperature drops to normal.

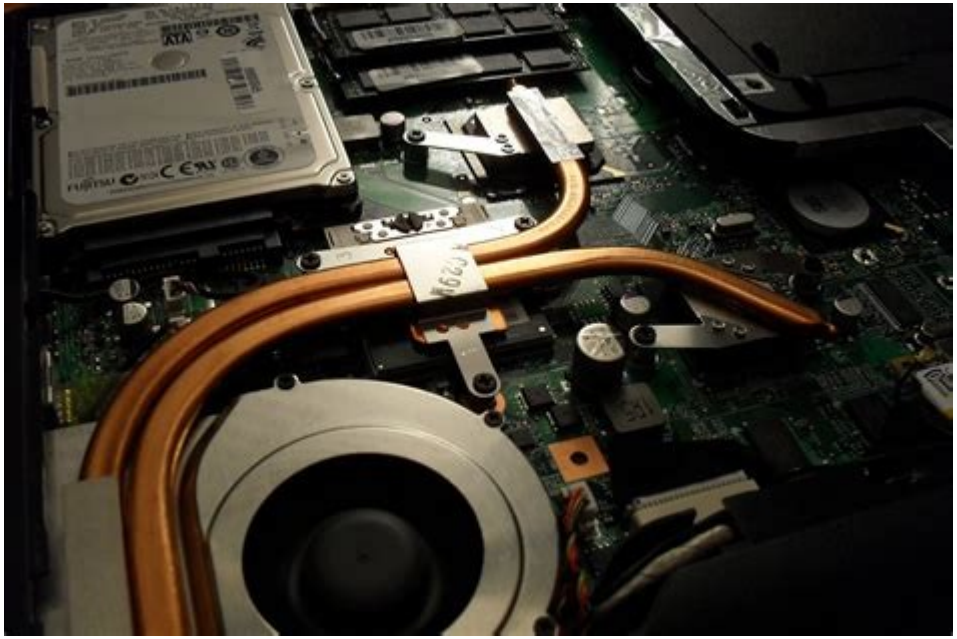
The Processor

- **Thermal paste:** This paste is placed between the processor and the heat sink to help draw the heat away from the processor and pass it through the heat sink.
- **Fanless/passive:** There are also fanless, or passive cooling mechanisms that can be used to cool processors. These essentially look like a spinning heat sink, but they do not have a noisy fan sitting on top to keep it cool. There are two major benefits of this cooling technique over fans: They are quiet and they do not collect dust.
- **Heat pipes:** A heat pipe is designed to transfer heat from a hot temperature source by vaporizing a form of coolant liquid that is then vacuumed away from the heat source to a cooler interface. The vapor can then be rerouted from the cool source to the heat source again as a liquid to perform the cooling process again.

Fanless/passive



Thermal paste



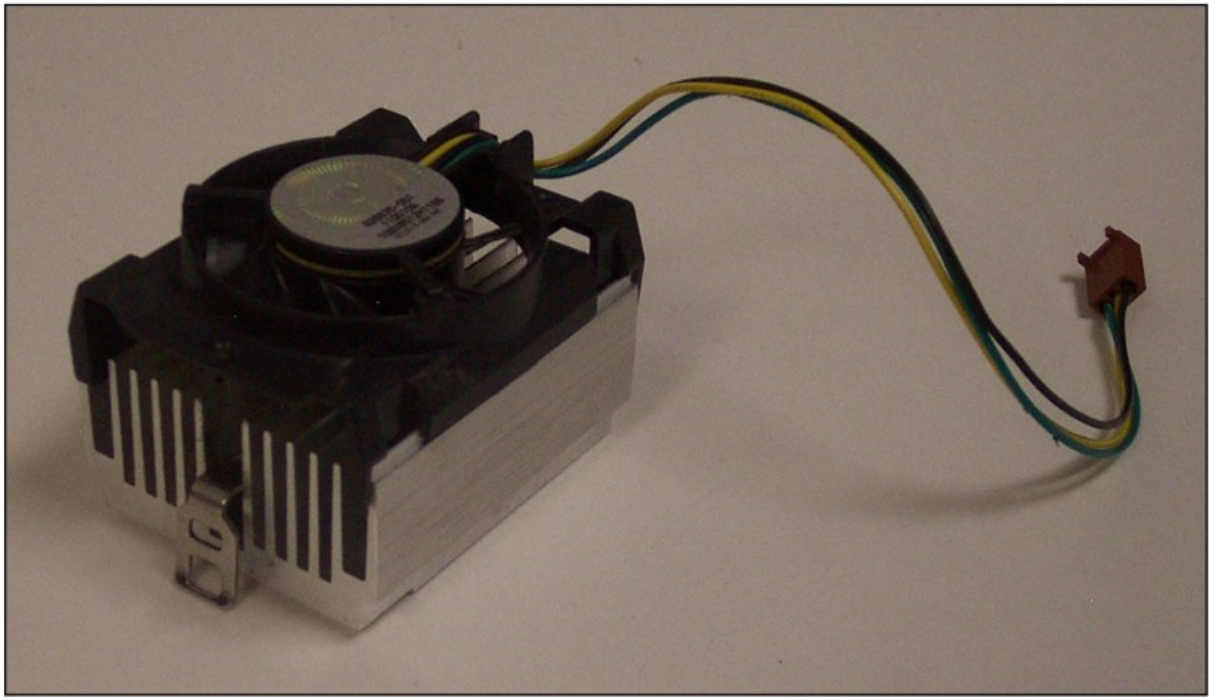
Heat pipes

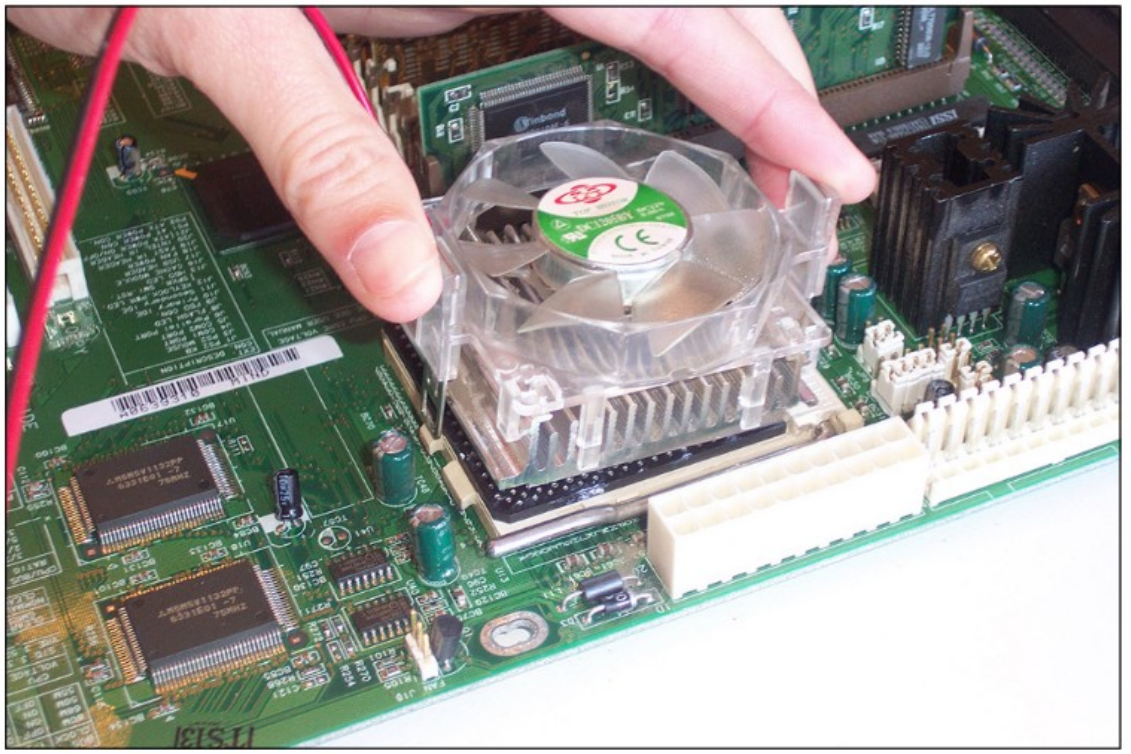
Liquid-based cooling

The Processor

Heat sinks and CPU fans

- Due to the size of the Pentium processor and the number of transistors passing current, the chip reached undesirable levels of heat, which caused it to become unstable.
- Thus, many of the Pentium processors came with either a cooling fan or heat sinks.
- Heat sinks are a group of metal-like pins that are placed on the chip to draw heat away from it.
- A cooling fan is a small fan placed on top of the processor.
- The function of the cooling fan is to pull the hot air away from the processor, helping to keep the processor cool. Some processors may get so hot that a heat sink may not be enough of a cooling device; in this case, the manufacturer may place a fan on top of the heat sink. The figure below shows you what a heat sink looks like.





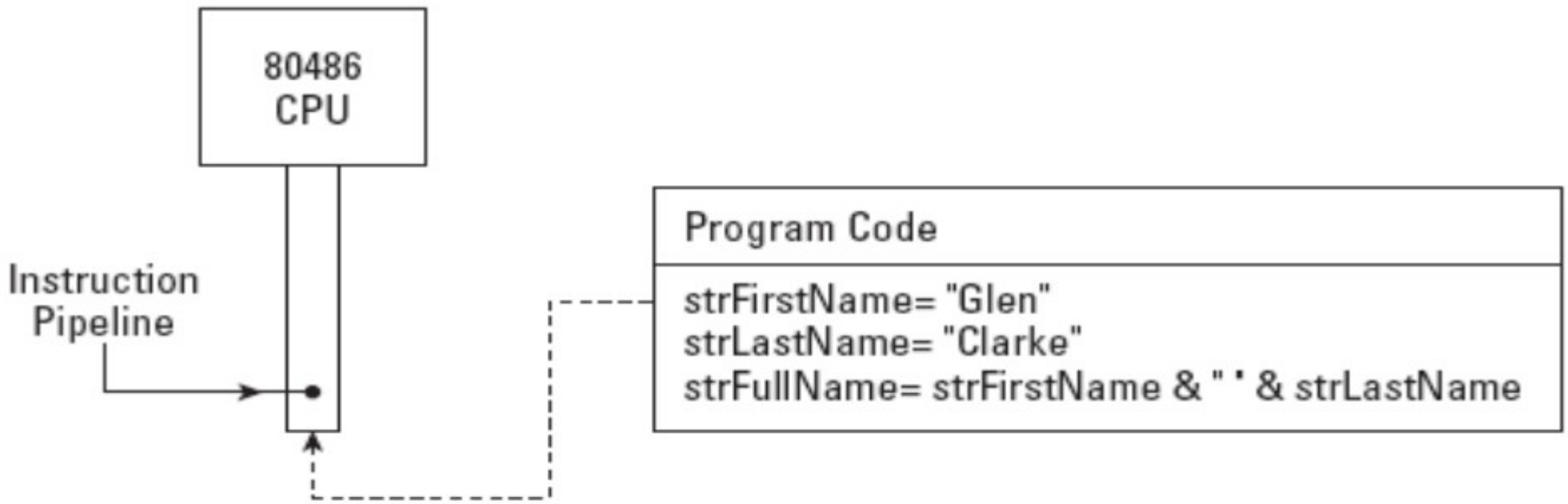
The Processor

Superscalar design

- Before the Pentium came along, processors used one instruction pipeline. This meant that when an application executed, it would run each stage of the application job one step after the other.
- For example, if an application has three lines of code, each line of code can only be processed after the previous line of code is fully completed. This creates a delay, or wait time, that slows performance

The Processor

Superscalar design



Single instruction pipelined processor executing application code

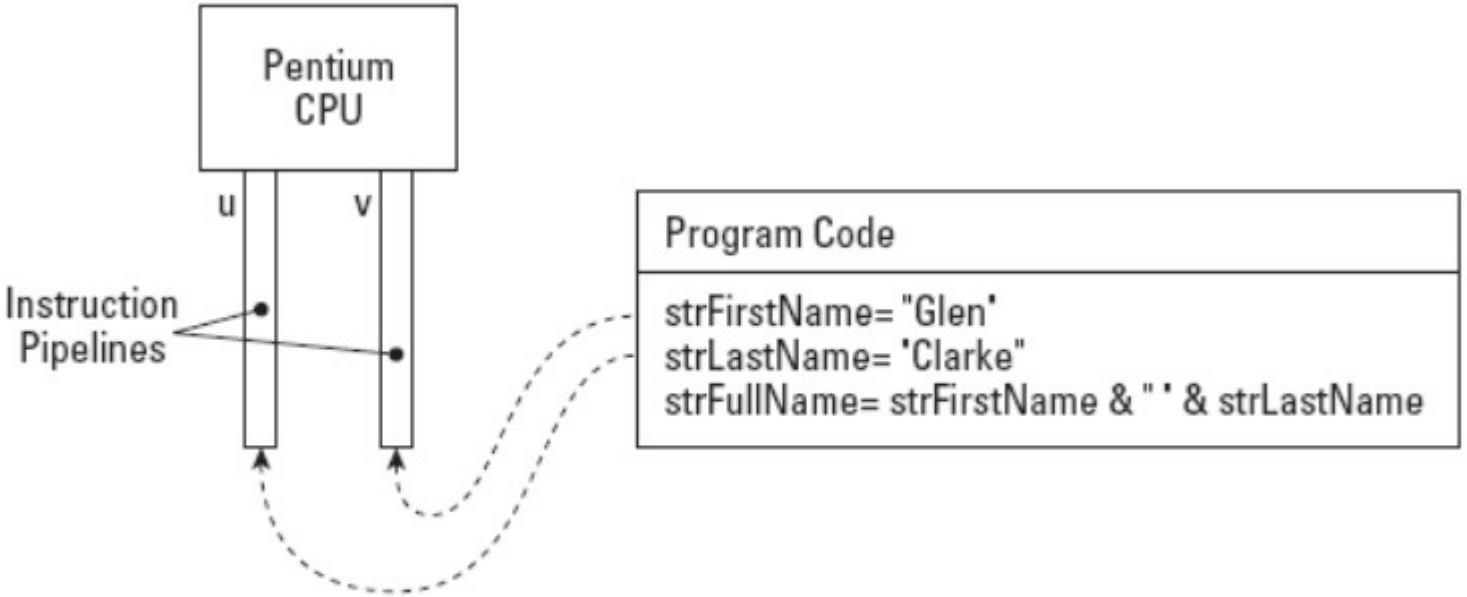
The Processor

Superscalar design

- The Pentium processor has two instruction pipelines, named U and V.
- Having two instruction pipelines enables the processor to execute two instructions at the same time. Thus, the three lines of program code, can be quickly executed on a Pentium processor because Lines 1 and 2 are processed at the same time, causing Line 3 to be processed that much faster. Notice that Lines 1 and 2 execute parallel to one another; therefore, /“parallel processing” is taking place.

The Processor

Superscalar design



Dual instruction pipelined processor processing application code

The Processor

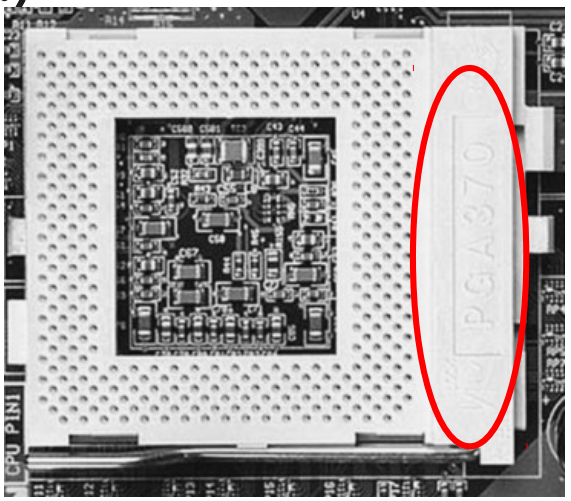
Identifying Socket Types

- Intel decided to develop a new standard for upgrading a processor on system boards, beginning with the 80486 chips and continuing with the Pentium class processors. This standard was processor sockets.
- A processor socket is a socket designed to hold a specific processor chip with the appropriate number of pins.
- This enabled Intel to develop new chips with compatibility in mind. They could design a new chip for an old socket so that customers could update their computers by dropping the new processor in the compatible socket.
- Popular Pentium processors supported mainly Socket 5 with 320 pins or Socket 7 with 321 pins. Thus, to add a Pentium processor to a system board, you would have to find out what socket existed on that board, then purchase a CPU that would fit in that socket. You would also have to remember to match the voltage of the board to the voltage required by the CPU

The Processor

Identifying Socket Types

- Sockets are normally labeled by type along the side of the socket. For example, in photo, the socket is labeled as PGA 370, meaning that it is Socket 370 and will hold any processor designed for Socket 370. (Socket 370 is a socket that holds a processor containing 370 pins.)



Example: This Table lists the different types of sockets and the processors that support them. It also shows the number of pins associated with the different types of sockets.

Socket	Processor	Number of Pins
Socket A	Later Athlon, Duron, and Athlon XP	462
Socket 4	Pentium 60/66	273
Socket 5	Pentium 75-133	320
Socket 7	Pentium 75-200	321
Socket 8	Pentium Pro	387
Socket 370	Celeron and Pentium III	370
Socket 418	Itanium	418
Socket 423	Pentium 4	423
Socket 478	Later Celerons and Pentium 4	478
Socket 603	Xeon (Pentium 4 version)	603
Socket 611	Itanium	611
Socket 940	Opteron	940

Example: This Table lists the different types of sockets and the processors that support them. It also shows the number of pins associated with the different types of sockets.

Socket	Processor	Number of Pins
Slot A	Athlon	242
Slot 1	Pentium II and Pentium III	242
Slot 2	Xeon	330
Socket 754	Turion 64, Athlon 64, Sempron	754
Socket 775 or LGA775 (also called Socket T)	Pentium 4, Pentium D, Celeron D, Core 2 Duo	775
LGA1366 (aka Socket B)	Intel Core i7 processor	1366
Socket 1156 (LGA)	Intel Core i3, Core i5, and Core i7 – 1st Generation (Lynnfield/Clarkedale)	1156
Socket 1155 (LGA)	Intel Core i3, Core i5, Core i7 – 2nd and 3rd Generation (SandyBridge and Ivy Bridge)	1155
Socket 1150 (LGA)	Intel Core i3, Core i5, Core i7 – 4th Generation (Haswell-DT)	1150

Example: This Table lists the different types of sockets and the processors that support them. It also shows the number of pins associated with the different types of sockets.

Socket	Processor	Number of Pins
LGA 2011 (aka Socket R)	Intel Core i7 processor (high-end workstations and servers)	2011
AM2	Opteron, Sempron, Athlon 64, Athlon 64 X2	940
AM2+	Athlon 64, Athlon 64 X2, Phenom, Phenom II	940
AM3	Phenom II	941
AM3+	AMD FX	942
FM1	AMD Llano	905
FM2	Athlon X2 and Athlon X4	904
FM2+	AMD Kaveri APU	906
F	AMD Athlon 64 FX, Opteron	1207

The Processor

Looking at Intel Processors

Pentium

- The original Pentium processor, released in 1993, was developed at speeds of 60 MHz and 66 MHz.
- The Pentium processor was a PGA chip that was placed in Socket 5 or Socket 7.
- Soon after its release, Intel marketed Pentium processors in 75, 90, 100, 120, 133, 150, 166, and 200 MHz flavors, which were really just clock multipliers of the original 60 MHz or 66 MHz systems.

The Processor

Looking at Intel Processors

Pentium

Clock multiplying is the concept that the processor will run faster than the mother board that the processor sits in.

- For example, the original Pentium processor ran on 60 or 66 MHz motherboards. Say that the computer is marketed as a Pentium90. Because you know that the motherboard runs at 60 or 66 MHz, you can determine that the 90 comes from 60 × 1.5 — meaning that the processor runs 1.5 times the speed of the motherboard.
- This is important because as a consumer, when you purchase a computer, you also want to make sure you know what the motherboard speed is — not just the advertised speed of the processor.

The Processor

Pentium Clock Multipliers

Processor	Motherboard Speed (MHz)	Multiplier	Processor Speed (MHz)
Pentium 90	60	1.5	90
Pentium 100	66	1.5	99
Pentium 120	60	2	120
Pentium 133	66	2	132
Pentium 150	60	2.5	150
Pentium 180	60	3	180
Pentium 200	66	3	198
Pentium II	100	4.5	450

The Processor

Pentium Pro

- In 1995, Intel released the Pentium Pro chip, which added a new level of performance to the Pentium processor.
- The Pentium Pro had all the characteristics of the Pentium processor—such as a 64-bit data bus and 32-bit registers—but it increased the address bus to 36-bit, which meant that the Pentium Pro could access 64GB of RAM. The speed of the Pentium Pro ranged from 120 MHz to around 200 MHz.
- The Pentium Pro included two additional features on its chip that helped it outperform the original Pentium. First, the Pentium Pro chip is really a two-chip team. One chip was the actual processor (with 16K of L1 cache, like the Pentium chip), but the other chip holds an extra 256K of cache memory. Because this cache memory is physically outside of the CPU, it is considered L2 cache

The Processor

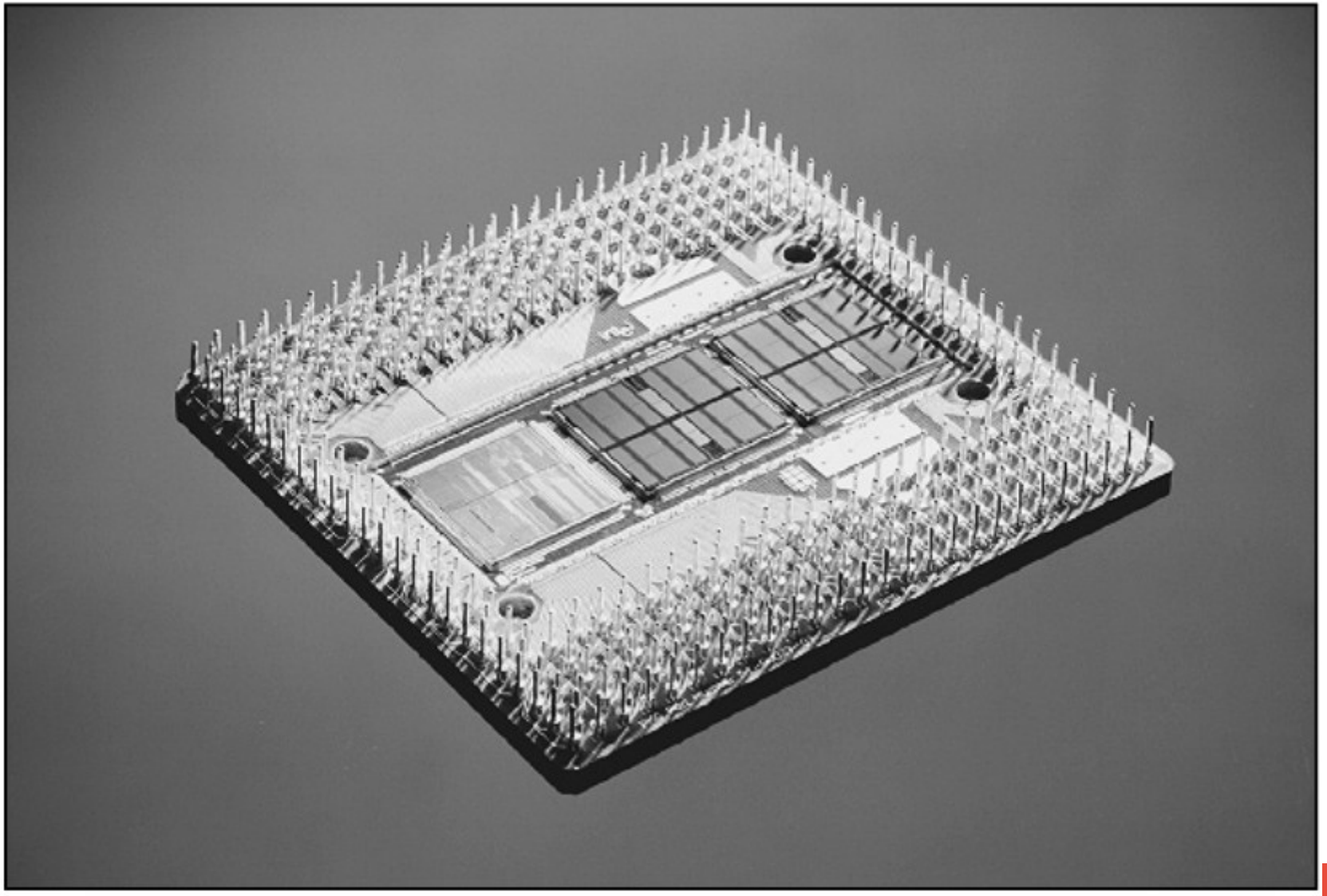
Pentium Pro

- The second feature that led to the performance gain of the Pentium Pro is dynamic execution, which has three stages: multiple branch prediction, data flow analysis, and speculative execution.

  » Multiple branch prediction is the idea that the processor will look ahead and predict a number of instructions that might be needed in the very near future.

  » Dataflow analysis occurs when the processor looks at the instructions it has predicted will be needed next and then assigns them a logical order of execution.

  » Speculative execution is the actual execution of a given instruction based on the prediction and the order of execution assigned.



The Processor

Pentium II

- In 1997, Intel produced the Pentium II, which was really just an enhanced Pentium Pro with speeds ranging from 233 MHz to 450 MHz. The Pentium II had a 64-bit data bus, a 36-bit address bus (64GB of RAM), and 64-bit registers.
- The Pentium II increased the amount of L1 cache that was integrated into the CPU to 32K, as opposed to 16K. The 32K of L1 cache was still divided into two equal channels: one 16K channel for data and one 16K channel for application code.
- Intel has packaged the Pentium II in the Single Edge Contact Cartride (SECC) that fits into Slot 1 on the system board. The Single Edge contact cartridge is a module enclosed two chips inside, one chip being the processor and the other chip being the 512K of L2 cache in order tom move it off the motherboard on to the processor. The following figure shows a Pentium II processor and Slot 1.


intel
Pentium II
intel
Pentium II

The Processor

SIMD Technology

- Another enhancement that accompanied the Pentium II was SIMD (Single Instruction Multiple Data). It is a technique employed to achieve data level parallelism .
- When I think of SIMD, I like to think of a playroom full of toddlers. Suppose there are five toddlers in the playroom and that these toddlers are at the entertaining age of two—the age, of course, when the toddlers are preparing for their teen years and they answer “no” to everything you say.
- You walk into the playroom and see that the five toddlers have found your box of darts and are throwing them at the walls. You are faced with a choice: you can either walk around to each child and explain why throwing darts at your walls is not a good thing (which means you will have to explain the same thing five different times) or you can have a good scream at the top of your lungs, which means that all the children will stop immediately and listen.
- SIMD works on the same basic principle. Suppose, for example, that you have a system running multiple processes at any given time and each process has data that it’s working with. If the processor has to give out instructions to modify a certain type of data, instead of explaining these instructions to each individual process one after the other (which takes a lot of time), the processor yells, or broadcasts, the instructions to everyone. Thus, the processor saves time and creates a much more efficient way to communicate information.

The Processor

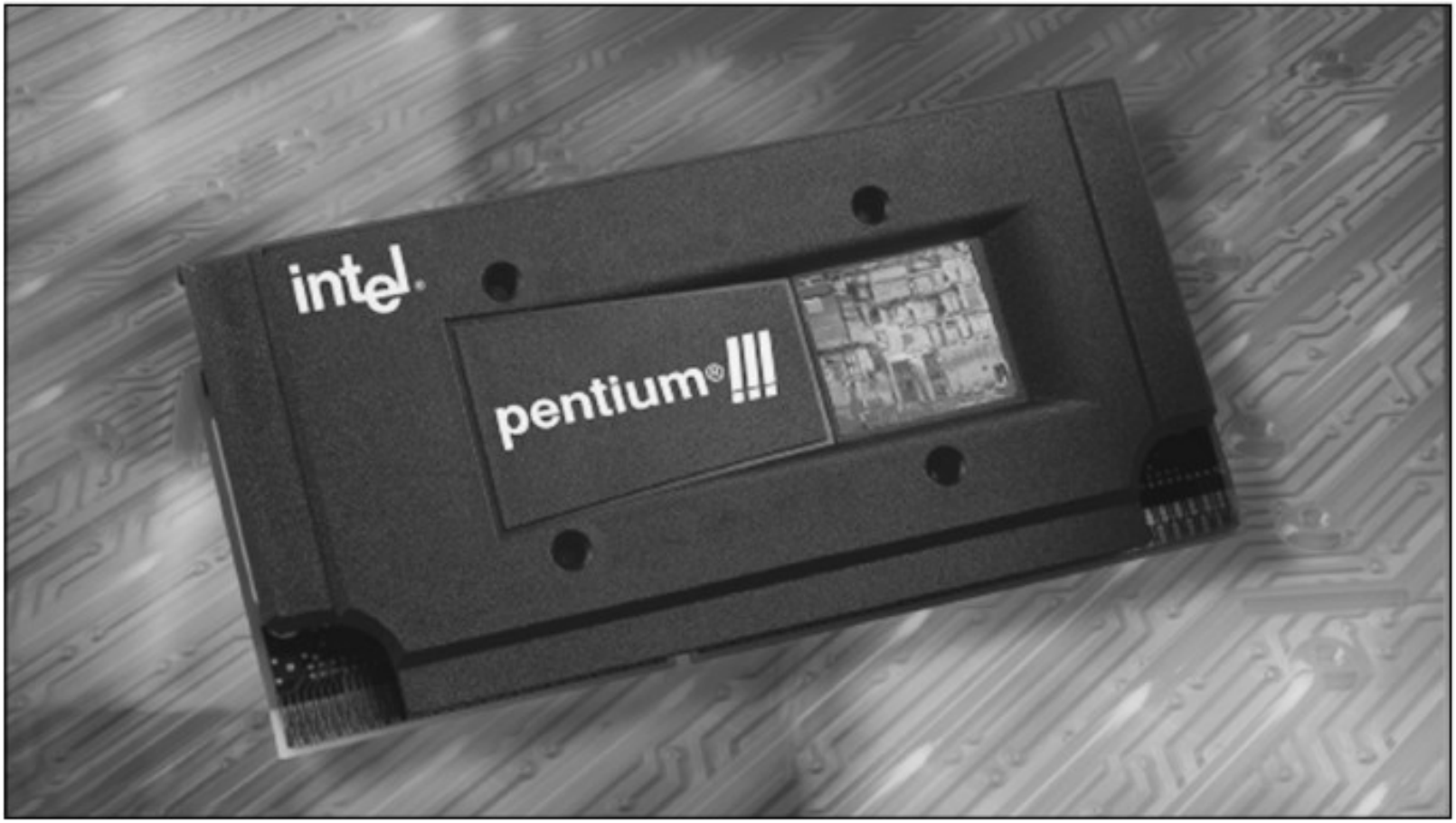
Celeron

- The Pentium II processor performs very well (and with all that cache memory, it should). Unfortunately, performance comes with a price. If you are not willing to pay that price, Intel has created a chip for you: the Celeron.
- The Celeron chip is nothing more than a Pentium II processor with the built-in L2 cache either removed or reduced and then sold at a cheaper price. The first-generation Celeron chip was code-named the Covington. It had no L2 cache memory on it.
- The second-generation Celeron was code-named the Mendocino. It contained 128K of L2 integrated into the processor itself. This L2 cache was not another chip sitting beside the processor, like the Pentium II.

The Processor

Pentium III

- The Pentium III processor shares many of the Pentium II's characteristics. It supports dynamic execution, MMX technology, and has either 256K or 512K of L2 cache. The Pentium III runs at a speed of 450 MHz to 1,000 MHz, or 1 GHz.
- The Pentium III chip offers 70 additional instructions that are integrated into the chip, enhancing the user's experience with 3D graphic applications. The Pentium III chip also supports a number of low power states to help conserve power when the system is not in use. This processor is designed to run on either a 100 MHz or 133 MHz system board.


intel
pentium® III

The Processor

Pentium III Xeon

- The Intel Pentium III Xeon runs at speeds of 866 Mhz or so, and are ideal for use in servers.
- The Xeon offers 256 KB of L2 cache and a system bus of either 100 Mhz or 133 Mhz.
- The Intel Pentium III Xeon is used for mid-range to high-end servers.
- The Xeon processor also includes a thermal sensor, which monitors the core temperature.


pentium II
xeon
intel

The Processor

Pentium 4

- It is a technology that was designed for the Internet and beyond.
- It is based on the all-new Intel NetBurstTM micro-architecture, and boasts 42 Million transistors.
- 400 MHz data transfers are supplied through a physical signaling scheme of quad pumping data transfers over a 1000 MHz clocked system bus.
- This system offers a performance increase of about three times that of the Pentium III.

The Processor

Itanium and Itanium II

- Intel created its first 64-bit processor in the Itanium and Itanium II processors and was marketed for server class–system or high-end PCs. Although the Itanium is a 64-bit processor and designed to run 64-bit software such as the 64-bit version of Windows, the Itanium can run some 32-bit code with the use of an emulator, but the code will run slower than if it were on a 32-bit processor. Special 64-bit editions of Windows can run on the Itanium processor, which enables you to take advantage of the 64-bit architecture.

The Processor

Itanium and Itanium II

- The original Itanium processor used a special packaging known as the pin array cartridge (PAC), which uses 418 pins. The Itanium II was packaged in organic land grid array (OLGA) — a variation of the PGA — but the chip is located on a processor card (a circuit board that holds the processor). The OLGA fits into Socket 611.
- The Itanium processor runs at around 1 GHz and contains a large block of cache memory: 32K of L1 cache, 96K of L2 cache, and 2MB or 4MB of L3 cache. The L3 cache is an additional block of cache memory located in the chip packaging.

The Processor

Pentium M

- For years, laptop manufacturers have been asking for smaller processors to place in laptop systems, and they finally have their wish. A number of processors have come out with the M version, which stands for mobile. The mobile versions of the processors are smaller than the processors that go in desktop systems, so they fit better and also use a lot less power. The benefit of using less power also means that they run much cooler
- Because the mobile versions of the processors use less power, they also run a little
- slower than their desktop counterparts. Some popular brands of mobile processors are the Intel Pentium III M and the Pentium M. Intel's big competitor, AMD, also has mobile versions of their processors: Athlon XP M and Mobile Duron. (Some manufacturers put the word mobile in the name of the processor instead of the letter M.)

The Processor

Intel Core 2

- Intel designed the Intel Core 2 to be its 64-bit, multicore processor. The Core 2 comes in three flavors:
  - Core 2 Solo: Single-core processor
  - Core 2 Duo: Dual-core processor on the one chip
  - Core 2 Quad: Actually two chips, with two cores per chip, packaged in a multichip module
- Core 2 processors range in speed from 1 GHz to around 3 GHz and fit into an LGA 775 socket, also known as Socket T. Core 2 processors come with either 2MB of L2 cache or 4MB of L2 cache

The Processor

Intel Atom

- Intel has created a processor to run on the now-popular Netbooks. A Netbook is a laptop-like computer — but much smaller — that is used primarily for Internet
- usage. The Netbook is much smaller and cheaper than a regular laptop system and is marketed for email and web browsing features. The Intel Atom has many characteristics of normal processors — it runs between 1 GHz and 2 GHz and contains 32K of L1 cache and 512K of L2 cache. Originally the Atom processor had one instruction pipeline, but there are versions with two instruction pipelines. There are also single core and dual core versions of the Atom processor.

The Processor

Intel Core i3/i5/i7 processors

- Intel has created a family of processors to satisfy lightweight system use or heavy system use that needs a powerful processor. The following are three common Intel processors found in new systems today:
- **Intel Core i3:** The Intel Core i3 processor is the least powerful of the three processors and ships with an integrated GPU and two processor cores. The i3 typically has a 64KB L1 cache, 256KB of L2 per core, and a shared block of L3 cache of approximately 3MB.
- **Intel Core i5:** The Intel Core i5 is the next step up with similar specs but with more power. The i5 processor can contain between two and four processor cores, with L3 cache memory ranging from 3MB to 8MB.
- **Intel Core i7:** Intel's highest-level processor is the Intel Core i7, which ships in different flavors as well. Depending on the model, the i7 ships with four or eight cores and an L3 cache ranging from 6MB to 12MB.

The Processor

Non-Intel Chips

One of Intel's major competitors is Advanced Micro Devices (AMD). AMD has developed a family of processors that compete with Pentium-class processors.

K6

The AMD K6 processor was designed to compete with the original Intel Pentium. The K6 has 64K of L1 cache, supports MMX technology, and has built-in branch prediction techniques. This processor has 321 pins, which means that it will fit into a Socket 7–supported motherboard.

The Processor

K6-2

The K6-2 processor is designed to compete with the Pentium II chip. It has 64K of L1 cache and 256K of L2 cache. The K6 also supports dynamic execution, MMX technology, and superscalar design. The K6-2 has added 3DNow! Technology—a number of additional instructions integrated into the chip to improve 3D graphic applications. The K6-2 chip also uses a 100 MHz system board speed. This is a big improvement over the 60/66 MHz system board speed that the original Pentiums were using. The K6-2 has 321 pins, which means that it will fit into a Socket 7–supported system board.

The Processor

K6-III

The K6-III processor is designed to compete with the Pentium III chip. This chip shares many of the features of the K6-2, including a 100 MHz system bus. One of its features was the tri-level cache. Not only can it take advantage of an L1 and L2 cache but also an L3 cache that can be included on the motherboard.

The Processor

Athlon

- The AMD Athlon chip has 128K of L1 cache and 512K of L2 cache. It supports improved dynamic execution, MMX technology, and 3DNow! technology. The Athlon chip runs at speeds of up to 1.2 GHz and is designed to run on a 200 MHz system bus speed.
- Unlike the K6-2 and K6-III, the Athlon is not a PGA-packaged chip that supports Socket 7. It uses its own socket type — Slot A, so called because the processor is packaged as an SEC. The Slot A socket is not compatible with Intel's Slot 1, which means that users have to purchase a motherboard designed for the Athlon chip.
- Later versions of the Athlon moved to the PGA package that has 462 pins. These PGA chips are placed in Socket A.

The Processor

Athlon XP

- After the Athlon chip was produced, Intel created the Pentium 4 chip. So AMD wanted to create a competing chip for the Pentium 4: namely, the Athlon XP. The Athlon XP is packaged as a PGA with 462 pins and is placed in Socket A. The Athlon XP runs at 2 GHz or more and contains 128K of L1 cache and 512K of L2 cache.

The Processor

Duron

- AMD wanted to create a processor that competed with each version of the Intel processors. So, if the Athlon XP competes with the Pentium 4, what competes with the Celeron? You guessed it — the Duron. The Duron has 128K of L1 cache and 64K of L2 cache. This processor is packaged as a PGA with 462 pins, which means that it, too, goes into Socket A.

The Processor

Opteron

- Just like the Duron was built to compete with the Intel Celeron, AMD created the Opteron to compete with Intel 64-bit Itanium processors.
- The Opteron runs at about 1.8 GHz and contains 128K of L1 cache and 1MB of L2 cache. The Opteron is packaged with a micro-PGA, which is made up of 940 pins and is placed in Socket 940. One of the major differences between the Opteron and the Itanium is that the Itanium cannot run 32-bit applications. AMD decided that the Opteron would run in a 32-bit or 64-bit mode, thus allowing it to run 32-bit applications.

The Processor

Athlon 64 and Athlon 64 X2

- The Athlon 64 — the successor to the Athlon XP — is the AMD 64-bit processor for desktop systems. The Athlon 64, with 128K of L1 cache and at least 512K of L2 cache built into the processor, is designed to compete with the Pentium 4.
- Although the Athlon 64 is a 64-bit processor, it has been designed to be backward compatible; it can run 32-bit code. The Athlon 64 X2 is the dual-core version of the Athlon 64. The Athlon 64 family processors fit into a number of sockets: Socket 754, Socket 940, and the AM2 socket.

The Processor

Phenom and Phenom II

- The Phenom and Phenom II pick up after the Athlon 64 and are the AMD triple- and quad-core processors. The Phenom, designed for desktop systems, uses the code names Toliman for the triple-core version and Agena for the quad-core version.
- The Phenom processor, which comes with 128K of L1 cache and 512KB of L2 cache per core, also has 2MB of shared L3 cache. The processor fits in the AMD AM2+ socket and runs between approximately 1.8 GHz and 2.6 GHz.
- The Phenom II also sits in the AM2+ socket and increases the shared L3 cache to 6MB! There were issues with the Phenom running on Windows Vista, but those bugs have been fixed for the Phenom II. The Phenom II has a triple-core version, code-named Heka, that runs between 2.6 GHz and 2.8 GHz. The quad-core version that is named Deneb runs between 2.5 GHz and 3.0 GHz.

The Processor

Turion 64 and Turion 64 X2

- The Turion 64 processor is the AMD 64-bit mobile processor for use in laptop computers. The Turion processor used to be called the Athlon Mobile 64, but AMD has moved to the new label of Turion 64 for its mobile processors. The Turion 64 is a single-core processor, and the Turion 64 X2 is the dual-core processor
- Turion 64 processors come with 128K of L1 cache and either 512K or 1024K of L2 cache. Both the Turion 64 and the Turion 64 X2 fit into Socket 754, and the newer chips fit in AMD Socket S7.
- The Athlon 64 X2 is the AMD dual-core processor, and the Phenom/ Phenom II have triple-core and quad-core versions. Also be familiar with the Turion being the AMD 64-bit processor for laptop computers.


AMD
AMD-K6™
AMD-K6-233ANR
3.2V CORE/3.3V I/O
C 9806GPDW
© 1997 AMD
233MHz
MALAY


AMD
AMD-K6™-2
AMD-K6-2/450 65°C
2.2V Core / 3.3V I/O
Z1541EX
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AMD
AMD-K6™-III
AMD-K6-III/400AHX
2.4V CORE/3.3V I/O
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HDZ550WFK2DGI
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Thanks For Attention